1   **METHODS AND APPARATUS FOR GENERATING IMAGES**

2

3   **CROSS REFERENCE TO RELATED APPLICATIONS**

4   This application is related to the following Patent Applications: US

5   Patent Application Serial No._____ filed September 10,

6   2003, entitled "Printing Digital Documents" (HP reference

7   200207150-1; Attorney docket 621239-6); US Patent Application

8   Serial No._____ filed September 10, 2003, entitled

9   "Location Patterns And Methods And Apparatus For Generating Such

10   Patterns" (HP reference 200310542-1; Attorney docket 621241-9);

11   US Patent Application Serial No._____ filed September 10,

12   2003, also entitled "Location Patterns And Methods And Apparatus

13   For Generating Such Patterns" (HP reference 200310543-1; Attorney

14   docket 621242-7); British Patent Application No._____ filed

15   September 10, 2003, entitled "Methods, apparatus and software for

16   printing location pattern" (HP reference 200300566-1; Attorney

17   docket JL3824); and, British Patent Application No._____

18   filed September 10, 2003, entitled "Printing of documents with

19   position identification pattern" (HP reference 200310132-1; Attorney

20   docket ASW1329).

21

22   **FIELD OF THE INVENTION**

23   The present invention relates to methods and apparatus for

24   generating position identifying pattern, which can be detected by a

25   suitable detection system. The pattern may be applied to a product

26   such as a document, which may be a form, label or note pad, or any

27   other form of product suitable for such marking, such as a packaging

28   product.

29

30   **BACKGROUND TO THE INVENTION**

1 It is known to use documents having such position identification

2 pattern in combination with a pen having an imaging system, such as

3 an infra red sensitive camera, within it, which is arranged to image a

4 small area of the page close to the pen nib. The pen includes a

5 processor having image processing capabilities and a memory and is

6 triggered by a force sensor in the nib to record images from the

7 camera as the pen is moved across the document. From these

8 images the pen can determine the position of any marks made on the

9 document by the pen. The pen markings can be stored directly as

10 graphic images, which can then be stored and displayed in

11 combination with other markings on the document. In some

12 applications the simple recognition that a mark has been made by

13 the pen on a predefined area of the document can be recorded, and

14 this information used in any suitable way. This allows, for example,

15 forms with check boxes on to be provided and the marking of the

16 check boxes with the pen detected. In further applications the pen

17 markings are analysed using character recognition tools and stored

18 digitally as text. Systems using this technology are available from

19 Anoto AB and described on their website www.Anoto.com.

20

21 In order to allow documents to be produced easily with the position

22 identifying pattern on them, it is desirable for the pattern to be

23 suitable for printing on the types of printer that are readily available

24 to a large number of users, such as an ink jet, laser jet or LEP

25 printer. These are digital printers and typically have a resolution of

26 300, 600 or 1200 dots per inch, and the accuracy with which each

27 dot can be located is variable. Also such printers are generally either

28 monochrome, or, if they are colour printers, have only a small

29 number of ink colours. Therefore, if it is desired to print position

30 coding pattern on a part of a product which has human visible

31 content on it as well, it can be a problem to ensure that the position

1 identifying pattern can be distinguished from the content by the
2 reading device, and that the content remains clearly visible to the
3 human eye, and distinguishable over the content.

4

5 **SUMMARY OF THE INVENTION**

6 According to a first as aspect of the invention there is provided a
7 method of generating an image comprising a position identifying
8 pattern and a content feature, the method comprising the steps of:
9 generating the pattern and the content feature each as a plurality of
10 graphical elements, and superimposing the content feature and the
11 pattern, wherein the content elements are smaller than the pattern
12 elements in at least one dimension. This can enable the pattern
13 elements within the superimposed area to be machine read, for
14 example by a digital pen.

15

16 The step of generating the content feature may comprise the steps
17 of: defining the content feature, determining whether the content
18 feature is to be superimposed on the pattern and, if it is, converting
19 the content feature so that it comprises said content elements. This
20 ensures that substantially any content feature can be printed with the
21 pattern. Clearly some initial content features will be modified more
22 than others in the conversion process to enable them to be
23 distinguished from the pattern. Content features which are already
24 formed from a number of graphical elements may simply require
25 changes to the size or spacing of those elements. Content features
26 which are initially solid colour, for example solid black, will need to
27 be broken down into separate graphical content elements.

28

29 The method may comprise, before the converting step, determining
30 whether the content feature already comprises said content elements
31 and, only if it does not, performing the converting step. This allows

1 features which are already in a form which can be superimposed on

2 the pattern, without preventing the pattern from being read, to be

3 printed in their original form without undergoing any further

4 modification.

5

6 The content marks may be smaller in two dimensions, which may be

7 orthogonal dimensions, than the pattern marks, and may each be

8 smaller in area than the pattern marks.

9

10 The difference in size between the pattern elements and the content

11 elements, which is required to enable the pattern to be machine

12 read, will depend on the details of the reading device. If the reading

13 device is arranged to recognize marks in a predetermined range of

14 sizes as being pattern elements, then the content elements need to

15 be of a size that is well outside that range to ensure that the reading

16 device does not erroneously identify the content elements as pattern

17 elements. For example the content elements may be no bigger than

18 half as big, in said one dimension, as the pattern elements. Where

19 the content elements comprise discrete dots, they may be, on

20 average, no bigger than a third, or even a quarter, of the area of the

21 pattern elements.

22

23 When applied to a product the pattern elements may each be formed

24 from a plurality of dots or pixels merged together to form a

25 substantially solid mark, and the content elements may each be

26 formed from at least one dot or pixel. This is how the product can be

27 printed on a printer, such as an inkjet, laser jet or LEP printer. Such

28 printers apply ink or toner in a large number of discrete areas, or

29 pixels, which are the smallest areas that the printer can mark

30 individually. The content elements may therefore each comprise a

31 single pixel, thereby being as small as the printer can make them.

1   Alternatively they may each be made up of a plurality of pixels

2   merged together into a single mark.

3

4   The pattern and the content may be printed substantially

5   simultaneously in a one-pass printing process, i.e. on a single pass

6   of a carrier through the printer. This allows the product, which may

7   be a document, label, packaging article, or any other printed product,

8   to be printed on demand on ordinary plain paper, card or other

9   carrier material. Alternatively the content and the pattern may be

10   printed onto the product separately, for example the content may be

11   printed onto the product which has already been printed with the

12   position identifying pattern.

13

14   The present invention is particularly suitable to monochrome printing.

15   However, it can also be used with colour printers, and may indeed be

16   advantageous under some circumstances. For example, colour

17   printers can often be set to print in grey scale, which causes them to

18   mix the different coloured toners, such as cyan, magenta and yellow,

19   to produce different shades of grey. When operating in this mode

20   colour printers can advantageously be operated according to the

21   invention. Also where a colour printer has run out of one or more ink

22   colours it may become necessary to print the content and the

23   position identifying pattern using the same colour, for example to

24   print some of the content in black ink as well as the pattern. Again, in

25   these circumstances, the present invention can usefully be used.

26

27   The density of the content elements, which may for example be

28   measured as the total area of content elements per unit area of the

29   image, may be greater than the density of the pattern elements,

30   which may be measured as the total area of the pattern elements per

31   unit area of the image. As the density of the content elements

1   increases the visibility, to a human reader, of the content over the
2   pattern increases, but the ease with which the pattern can be
3   machine read by a reading device, such as a digital pen, decreases.
4   For example, where the content is to be applied as a grey scale, the
5   density may be measured as the grey scale of the content. This is
6   particularly applicable to monochrome printing methods. Where
7   colour printing or marking methods are used for the content, the
8   density may be defined as the average reflectivity of the defined
9   content within a particular wavelength. For example if the pattern is
10   to be produced in some regions using a marking material having a
11   reflectivity in a particular wavelength, then the density can be defined
12   as the average reflectivity of the content within that range of
13   wavelengths. Other measures of density may also be used. For
14   example, where the content is to be applied as a grey scale, the
15   density may be measured as the grey scale of the content. This is
16   particularly applicable to monochrome printing methods. Where
17   colour printing or marking methods are used for the content, the
18   density may be defined as the average reflectivity of the defined
19   content within a particular wavelength. For example if the pattern is
20   to be produced in some regions using a marking material having a
21   reflectivity in a particular wavelength, then the density can be defined
22   as the average reflectivity of the content within that range of
23   wavelengths.

24

25   The minimum possible contrast between the individual pattern marks
26   and the content, which allows the reading device to detect the
27   pattern, depends on various factors relating to the reading device,
28   including the resolution of its imaging device and the processing
29   methods it uses to analyse the pattern.

30

1   According to a second aspect of the invention there is provided a
2   corresponding system for generating an image.

4   According to a third aspect of the invention there is provided a
5   product having a position identifying pattern and a content feature
6   applied to it, wherein the pattern comprises a plurality of discrete
7   pattern marks each being of at least a predetermined size, the
8   content feature comprises content marks, the content and the pattern
9   are superimposed on each other within at least an area of the
10 product, said area having two dimensions, and within said area the
11 content marks are smaller than the pattern marks in at least one of
12 the dimensions.

14 According to a fourth aspect of the invention there is provided a
15 method of analysing a position identifying pattern on a product, the
16 product having thereon the position identifying pattern comprising a
17 plurality of pattern elements and a content feature comprising a
18 plurality of content elements, the content elements being smaller
19 than the pattern elements, the method comprising the steps of
20 forming an image of an area of the pattern and the content, and
21 processing the image to extract the pattern from the content on the
22 basis of the relative sizes of the pattern elements and the content
23 elements.

25 A corresponding system for analysing a position on a product is also
26 provided.

28 According to a further aspect of the invention there is provided a data
29 carrier carrying data arranged to control a computer system to
30 operate as a system according to the invention, or to carry out the
31 methods of the invention.

1

2 The data carrier can comprise, for example, a floppy disk, a CDROM,

3 a DVD ROM/RAM (including +RW, -RW), a hard drive, a non-volatile

4 memory, any form of magneto optical disk, a wire, a transmitted

5 signal (which may comprise an internet download, an ftp transfer, or

6 the like), or any other form of computer readable medium.

7

8 Preferred embodiments of the present invention will now be

9 described by way of example only with reference to the

10 accompanying drawings.

11

12 **BRIEF DESCRIPTION OF THE DRAWINGS**

13 **Figure 1** shows a document according to an embodiment of the

14 invention and a digital pen according to and embodiment of the

15 invention;

16

17 **Figure 2** shows a part of a position identifying pattern on the

18 document of Figure 1;

19

20 **Figure 3** shows a part of the position identifying pattern of the

21 document of Figure 1 with a content feature superimposed thereon;

22

23 **Figure 4** shows a part of the position identifying pattern of the

24 document of Figure 1 with a darker content feature superimposed

25 thereon;

26

27 **Figure 5** shows a system, according to an embodiment of the

28 invention, for printing the document of Figure 1;

29

1 **Figure 6** shows some of the functional units within the computer of

2 the system of Figure 5;

3

4 **Figure 7** shows a part of a position identifying pattern and content on

5 a document according to a further embodiment of the invention; and

6

7 **Figure 8** shows part of a process according to an embodiment of the

8 invention for analysing the pattern and content on the document of

9 Figure 1.

10

11 **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

12 Referring to Figure 1, a document 2 according to an embodiment of

13 the invention for use in a digital pen and paper system comprises a

14 carrier 3 in the form of a single sheet of paper 4 with position

15 identifying markings 5 printed on some parts of it. The markings 5,

16 which are not shown to scale in Figure 1, form a position identifying

17 pattern 6 on the document 2. Also printed on the paper 4 are further

18 markings 7 which are clearly visible to a human user of the

19 document, and which make up the content of the document 2. The

20 content 7 is in the form of a number of lines which extend over, and

21 are therefore superimposed upon, the pattern 6.

22

23 The pen 8 comprises a writing nib 10, and a camera 12 made up of

24 an infra red (IR) LED 14 and an IR sensor 16. The camera 12 is

25 arranged to image a circular area of diameter 3.3mm adjacent to the

26 tip 11 of the pen nib 10. A processor 18 processes images from the

27 camera 12 taken at a specified sample rate. A pressure sensor 20

28 detects when the nib 10 is in contact with the document 2 and

29 triggers operation of the camera 12. Whenever the pen is being used

30 on an area of the document 2 having the pattern 6 on it, the

31 processor 18 can determine from the pattern 6 the position of the nib

1   10 of the pen whenever it is in contact with the document 2. From

2   this it can determine the position and shape of any marks made on

3   the patterned areas of the document 2. This information is stored in a

4   memory 22 in the pen as it is being used. When the user has finished

5   marking the document 2, this is recorded in a document completion

6   process, for example by making a mark with the pen 8 in a send box

7   9. The pen is arranged to recognise the pattern in the send box 9

8   and send the pen stoke data to a pen stroke interpretation system in

9   a suitable manner, for example via a radio transceiver 24 which

10 provides a Bluetooth radio link with an internet connected PC.

11 Suitable pens are available from Logitech under the trade mark

12 Logitech Io.

13

14 Referring to Figure 2, the position identifying pattern 6 is made up of

15 a number of graphical elements in the form of black ink dots 30

16 arranged on an imaginary grid 32. The grid 32, which is shown in

17 Figure 2 for clarity but is not actually marked on the document 2, can

18 be considered as being made up of horizontal and vertical lines 34,

19 36 defining a number of intersections 40 where they cross. The

20 intersections 40 are of the order of 0.3mm apart, and the dots 30 are

21 of the order of 100µm across. One dot 30 is provided at each

22 intersection 40, but offset slightly in one of four possible directions

23 up, down, left or right, from the actual intersection 40. The dot offsets

24 are arranged to vary in a systematic way so that any group of a

25 sufficient number of dots 30, for example any group of 36 dots

26 arranged in a six by six square, will be unique within a very large

27 area of the pattern. This large area is defined as a total imaginary

28 pattern space, and only a small part of the pattern space is taken up

29 by the pattern on the document 2. By allocating a known area of the

30 pattern space to the document 2, for example by means of a co-

1 ordinate reference, the document and any position on the patterned

2 parts of it can be identified from the pattern printed on it. An example

3 of this type of pattern is described in WO 01/26033.

4

5 Referring to Figure 3, the content markings 7 are made up of a

6 regular square array of discrete, equally spaced, graphical elements,

7 in the form of content dots 50, each of which is significantly smaller

8 in both the horizontal and vertical dimensions, and in area, than each

9 of the pattern dots 30. The content dots 50 are also spaced apart in

10 both the horizontal and vertical directions. In this case the content

11 dots 50 are each formed from a single dot or pixel of a 1200dpi

12 printer, and each dot is separated from the adjacent dots 50, both

13 vertically and horizontally, by a space equivalent to the size if one

14 single printer pixel. They therefore have a nominal diameter of 21μm,

15 and are spaced apart so that their centres are spaced at intervals of

16 twice their diameter, i.e. 42μm. If the content dots 50 were exactly

17 circular and had a diameter of exactly 21μm, then the content dots

18 50 would cover about 20% of the area to which they are applied, the

19 spaces between them would make up the other 80%. In practice,

20 each printer dot is arranged to be larger in diameter than the spacing

21 between the dot centres, so as to ensure that total coverage is

22 achieved in a black area where all of the dots are applied. Therefore

23 the coverage produced by the content dots 50 will be higher than

24 20%. Assuming the pattern dots are 100μm in diameter, they cover

25 about 9% of the area to which they are applied. This means that, to

26 the human eye, the content is clearly visible and distinguishable as a

27 darker shade of grey over the position identifying pattern.

28

29 Referring back to Figure 1, the processor 18 in the pen 8 receives a

30 digital image of the combined pattern and content, as shown in

1   Figure 3, from the camera 12 and then processes the image in a

2   known manner to identify the pattern dots 30. The processor 18 can

3   identify the pattern dots 30 provided they are within a predetermined

4   size range around 100 μm diameter, have at least a predetermined

5   contrast with the background, defined as the relative level of

6   absorption of light within a specific range of wavelengths, and are

7   spaced apart with a grid spacing that is within a predetermined range

8   around 300 μm. Therefore, because the content dots 50 are

9   considerably smaller than the acceptable range of pattern dot sizes,

10   and have a completely different spacing from the pattern dots 30,

11   and produce a light enough grey scale to maintain sufficient contrast

12   with the pattern dots 30, the pen can still identify the pattern dots 30

13   where the content 7 is superimposed on the pattern. The processor

14   then analyses the positions of the pattern dots 30 and determines

15   from them the position of the imaged area within the total pattern

16   space. This process is then repeated at each sample period, so that

17   the pen can determine the position of pen strokes made on the

18   document 2 as they are made. This pen stroke data is stored as in

19   the pen's memory 22 for transmission to a pen stroke interpretation

20   device as described above.

21

22   The density, or grey scale, of the content dots can vary up to a

23   certain limit, above which the pen 8 is unable to reliably read the

24   pattern 7. Using the normal grey scale where 0 represents black and

25   255 represents white, a grey scale of from 255 down to about 200,

26   which represents about 30% coverage of black ink on a white carrier,

27   can be used with the pen 8. Figure 4 shows an area of a document in

28   which the pattern dots 30 and the content dots 50 are the same size

29   as in Figure 3, but the content dots are closer together covering

30   about 75% of the document surface. In this case the contrast

1   between the pattern dots 30 and the surrounding areas of content

2   dots 50 is not sufficient for the pen 8 described above to be able to

3   read the pattern dots.

4

5   Referring to Figures 5 and 6, a very simple system according to an

6   embodiment of the invention for producing printed documents having

7   the position identifying pattern on them comprises a personal

8   computer (PC) 200 and a printer 202. The PC 200 has a screen 204,

9   a keyboard 206 and a mouse 208 connected to it to provide a user

10 interface 209 as shown generally in Figure 6. As also shown in

11 Figure 6, the PC 200 comprises a processor 210 and a pattern

12 allocation module 212 which is a software module stored in memory.

13 The pattern allocation module 212 includes a definition of a total area

14 of pattern space and a record of which parts of that total area have

15 been allocated to specific documents, for example by means of

16 coordinate references. The PC 200 further comprises a printer driver

17 214, which is a further software module, and a memory 216 having

18 electronic documents 218 stored in it. The user interface 209 allows

19 a user to interact with the PC 200.

20

21 The printer 202 can be any printer which has sufficient resolution to

22 print the pattern dots 30 and the content dots 50. In this case it is a

23 1200 dots per inch (dpi) monochrome laser jet printer. It will be

24 appreciated that the dimensions of the content dots 50 correspond to

25 the dimensions of single pixel of ink from a 1200 dpi printer, and that

26 the spacing between the content dots 50 is twice the spacing of the

27 printer pixels. This enables the printer to print the content dots 50 as

28 single ink dots and the pattern dots 30 as groups of ink dots, for

29 example about 12 dots. The printer dots are not exactly circular but

30 each comprise an irregular mark of ink on the document 2. However

31 the exact shape of the content dots 50 is not important as the human

1   eye cannot see their shape, and the pattern dots 30, because they

2   are made up of a group of printer dots, are close enough to a regular

3   shape to be read by the pen 8. Because they can be distinguished by

4   the pen 8 by virtue of their size, the pattern dots 30 and content dots

5   50 can be printed using the same type of ink from the monochrome

6   printer. Where a colour printer is used, the ink which is used for the

7   pattern, which would typically be a black ink, can also be used for

8   part of the content where appropriate.

9

10 In order to produce the printed document 2 the processor 210

11 retrieves an electronic document 218, which may be in the form of a

12 PDF file, from the memory 216 and sends it to the printer driver

13 together with instructions as to whether it is to be printed with pattern

14 or not. The electronic document 218 contains a definition of the

15 content 7, and the areas of the document 2 which can have the

16 pattern 6 printed on it. The printer driver then determines from the

17 instructions received whether the document is to be printed with

18 pattern or not. If the document is to be printed without pattern on it,

19 the content is sent for printing. If the document is to be printed with

20 pattern on, the printer driver converts checks the nature of the

21 content to determine whether it is already made up of graphical

22 elements of a suitable format to enable the pattern to be read when

23 the pattern and content are superimposed. If the content is already

24 made up of suitable graphical content elements, then the printing

25 process can proceed. If the content is not suitable made up, for

26 example if it includes areas of solid black, then it is converted so that

27 it is made up entirely of content elements 50 as described above.

28

29 When it is determined that the content is all in a suitable format, the

30 printer driver 214 requests the required amount of pattern from the

31 pattern allocation module 212 which allocates by means of

1 coordinate references an area of the pattern space to the document,

2 generates the pattern 6 for that area using a pattern generation

3 algorithm, and communicates the details of the pattern including the

4 positions of all the required dots, back to the printer driver 214. The

5 printer driver 214 then combines the content 7 and the pattern 6 into

6 a single electronic file. This file therefore forms a combined

7 electronic definition of both the pattern and the content. The printer

8 driver then converts the content 7 and the pattern 6 to a format, such

9 as a postscript file, suitable for the printer 202, and sends it to the

10 printer which prints the content 7 and the pattern 6 simultaneously in

11 a one-pass process, i.e. on a single pass of the paper, on which the

12 document is printed, through the printer.

13

14 In practice the various components of the system can be spread out

15 over a local network or the internet. For example the pattern

16 allocation module 212 can be provided on a separate internet

17 connected server so that it can be accessed by a number of users.

18

19 While the use of a 1200 dpi printer is described above, a similar

20 result can also be achieved with lower resolution printers, such as

21 600 dpi printers. For a 600 dpi printer, the approximate diameter if

22 each ink dot is 42μm. This is therefore still well below the minimum

23 diameter for a dot that will be recognized by the pen 8 as a pattern

24 dot. Therefore if the content is printed as single, spaced apart ink

25 dots or pixels from a 600 dpi printer, and the pattern dots are printed

26 as groups of ink dots, then the content and pattern can be printed

27 simultaneously on a 600 dpi printer. Again the grey scale of the

28 content dots needs to be kept at such a level that it will not interfere

29 with the pens ability to identify the pattern dots. A maximum of about

30 30% grey has been found to work with the Logitec Io ™ pen.

1

2 If other methods of printing, such as offset printing are used, the

3 resolution of the printed pattern and content can be much higher than

4 with inkjet or laser jet printers. This gives greater freedom in the

5 manner in which the content can be produced. Figure 7 shows an

6 example of a document in which the position identifying pattern is

7 again provided by a set of pattern dots 300, but the content is

8 produced as a set of lines 302, using the same ink as for the dots.

9 The content lines 302 are much narrower than the pattern dots 300

10 and spaced apart by a distance equal to about four times their width.

11 This means that they cover about 20% of the document surface. In

12 this case the pattern dots are again about 100μm in diameter and the

13 content lines 302 are about 20μm in width and spaced apart at a

14 pitch of about 100μm.

15

16 With the format of content and position identifying pattern described

17 above, it is possible to use various image processing techniques

18 within the pen processor 18 to help distinguish the content from the

19 pattern, for a given resolution of the camera 12 in the pen 8.

20 Because the content dots 50 are smaller than, and closer together

21 than, the pattern dots 30, spatial filtering can be used to select, from

22 all the marks on the document, those which make up the pattern dots

23 30. Spatial filtering is typically carried out using Fourier transforms,

24 for example as described in WO 01/75783. Referring to Figure 8, in a

25 modification to the embodiment described above, the processor 18 is

26 arranged to first receive, at step 300, an image of a viewed area of

27 the document 2. Then at step 302 it performs a Fourier transform on

28 the image which produces a map of the image in the spatial

29 frequency domain. Next at step 304, the elements of the spatial

30 frequency domain map which correspond to the spatial frequency of

1 the pattern 6 are selected, and the elements which correspond to the

2 spatial frequency of the content dots 50 are removed using a low

3 pass filtering process. At step 306, the frequency domain map is

4 transformed back to a new image, by reverse Fourier transform, to

5 produce an image containing the pattern 6 but not the content 7. The

6 modified image is then analysed by the processor 18 in the normal

7 way to determine the position of the pattern dots 30 at step 308.

8

9 When this Fourier transform method is used, the ability of the

10 processor 18 in the pen 8 to distinguish the pattern 6 from the

11 content 7 is increased, so the content 7 can be made darker than

12 that shown in Figure 3. For example the content shown in Figure 4

13 could potentially be distinguished using this method. Also the lined

14 content of Figure 7 can more easily be distinguished using the

15 Fourier transform method since the content lines only have a spatial

16 frequency in one direction, and the method of removing them is

17 therefore simplified.

18